Descriptions and Notes on Male Mealybugs (Homoptera: Pseudococcidae)*

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In a previous paper (Beardsley, 1960) I described the adult males of 30 mealybug species which occur in Hawaii. The males of five additional mealybugs are described below. These include one endemic Hawaiian form, *Pseudococcus peleae* Beardsley, males of which were not previously available; and four species not presently known to occur in Hawaii, but all of which are, or have been, of some economic importance in the continental United States. These are *Puto yuccae* (Coquillet), *Rhizoecus falcifer* Kunckel d' Herculais, *Pseudococcus comstocki* (Kuwana), and *Pseudococcus fragilis* Brain (=*gahani* Green). In addition, supplementary notes on the male of *Phenacoccus gossypii* Townsend and Cockerell are presented.

Two of the mealybug males described below, *P. yuccae* and *R. falcifer*, exhibit greater diversity of structure than males of the species studied previously. The study of these and of additional specimens of *Phenacoccus gossypii* has led me to venture a few comments on possible phylogenetic relationships, and also on the possible future use of males in the systematics of the Pseudococcidae.

I am indebted to the following persons who have furnished material for this study: Dr. Uzi Nur, Department of Genetics, University of California, Berkeley, for males of *Pseudococcus comstocki*, *Phenacoccus gossypii*, and *Rhizoecus falcifer;* Mr. Glen Finney, Department of Biological Control, University of California, Albany, for males of *Pseudococcus fragilis*; and Mr. Howard McKenzie, Entomology Department, University of California, Davis, for slide mounts of *Puto yuccae* males. This work was done under the direction of Dr. D. E. Hardy, Department of Zoology and Entomology, University of Hawaii, Honolulu, to whom I am indebted for his critical reading of the manuscript and helpful suggestions.

Since completing the manuscript I have received a copy of a recent study on the comparative morphology and taxonomy of male mealybugs by J. H. Giliomee (1961). This excellent piece of work raises several points which necessitate some changes in the present paper. Giliomee has provided very detailed descriptions of three species of *Pseudococcus*; two of these, *P. adonidum* (L.) and *P. maritimus* (Ehrhorn), I treated in considerably less detail in 1960. The third species treated by Giliomee is *P. fragilis* Brain, the male of which I have described below in a much less detailed manner.

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An interesting problem raised by Giliomee is the interpretation of the abdominal segmentation in both male and female mealybugs. In my previous paper I based my interpretation of abdominal segmentation of the male on the position of the posterior dorsal ostioles, which are present in both sexes. I equated the position of the ostioles in the male with Ferris' interpretation of segmentation in the female, which he, in turn, based largely on the position of the female gonopore (Ferris 1950, p. 5). By this interpretation the first abdominal segment is considered to be completely absent, and the second discernible only dorsally, in both sexes. Both Theron (1958) and Giliomee hold that the first abdominal segment is present and that the posterior dorsal ostioles lie on what is morphologically the 6th abdominal segment, rather than on the 7th. Primarily for the sake of consistency, I have employed the system here as was used in my previous paper. I do not wish to imply that I necessarily consider that this is the morphologically correct interpretation of abdominal segmentation in the Pseudococcidae, as it does not appear that the matter is yet settled completely.

Puto yuccae (Coquillett).

Pseudococcus yuccae Coquillett, 1890, WEST AMER. SCI. 7:43–45 (not seen).

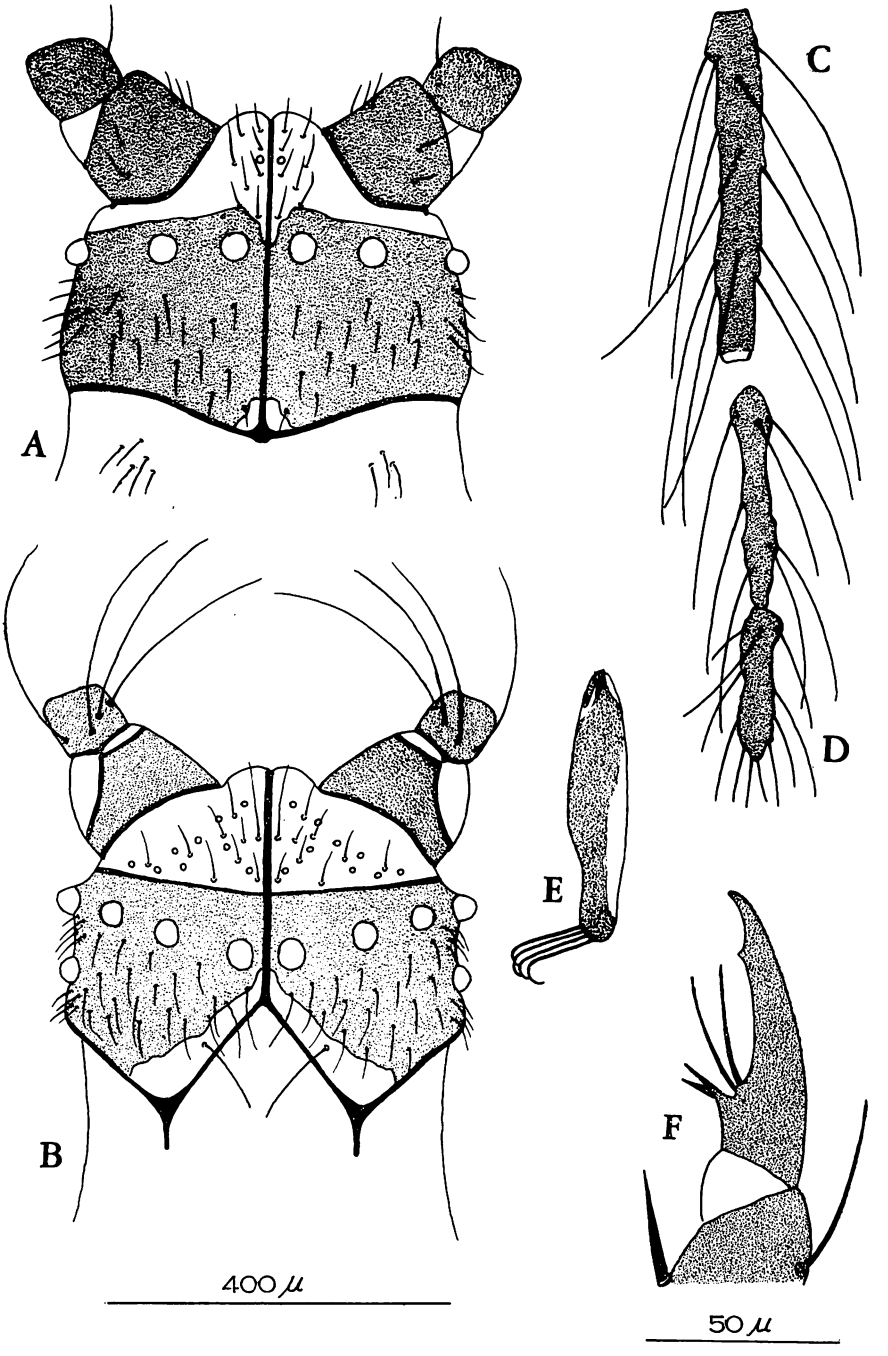
Ceroputo yuccae, Essig 1909. POMONA COLLEGE JOUR. ENT. 1:94–97 (includes brief description and figures of male).

Puto yuccae, Ferris 1950. ATLAS OF SCALE INSECTS OF NORTH AMERICA 5:213–215, fig. 80.

Male. Length of body (on slide) about 3.7 mm.; available specimens macropterous. Antenna 10-segmented, about 3.85 mm. total length; scape 145 μ long by 145 μ maximum width, pedicel 80 μ long by 90 μ wide; flagellar segments elongate, their margins somewhat irregular (fig. 1, C, D); third to seventh segments subequal, each about 400 μ long; eighth segment slightly shorter, about 350 μ long; ninth and tenth progressively shorter (fig. 1, D), about 280 and 210 μ long respectively. Antenna clothed with very long filamentous setae, about 260μ maximum length, those of distal segments somewhat shorter; without digitiform setae; specialized sensory setae on segments 9 and 10 only very slightly thicker than other setae. One or two very small fine setae, 15 to 18 μ long, arising on basal tubercle of each of long filamentous setae.

Head (fig. 1, A, B) with a pair of well-developed ocular sclerites extending completely around each side, each bearing a row of 7 simple eyes (each about 30 to 38 μ in diameter) near anterior margin, plus a single lateral ocellus on each side behind mid-lateral member of anterior row, about same diameter. Ocular sclerites meeting dorsally and ventrally along midcranial ridge. Midcranial ridge more strongly developed than in other pseudococcids studied,

FIG. 1. *Puto yuccae:* A, dorsal aspect of head; B, ventral aspect of head; C, 3rd antennal segment; D, 9th and 10th antennal segments; E, halter; F, claw of hind tarsus. (A to E to the same scale, F more enlarged.)


A
B
C
D
E
F
400 μ
50 μ

fused at its posterio-dorsal end with postocular ridges (which lie along posterior margins of ocular sclerites); ventrally forming juncture of two ocular sclerites, and fused at its posterio-ventral terminus with strongly developed preoral ridges. Preocular ridge moderately well developed along anterior margins of ocular sclerites ventrally, and laterally, where it articulates with antennal scape, not confluent with postocular ridge as in most other species. Ocular sclerites, behind anterior row of eyes, sparsely clothed with filamentous setae about 45–100 μ long; membranous areas of head anterior to ocular sclerites with a few similar setae. Area behind postocular ridges forming a well developed membranous "neck."

Thoracic sclerotization more strongly developed than in other pseudococcids studied. Propleura relatively well-developed, their maximum width and length approaching those of fore coxae. Pronotal ridges well developed. A small sclerotized area contiguous with pronotal ridge present on each lateral margin (homologous with pronotal sclerite of Giliomee, 1961). Prosternum more strongly developed than in other pseudococcids, with a definite pair of sternal apophyses. Mesothorax well developed as in other winged male pseudococcids; mesopostnotum somewhat larger and less noticeably separated from scutellum than in others studied. Metanotum not strongly developed, represented by a pair of indistinctly joined, weakly sclerotized patches. Metapleurites well developed; each with two bar-like dorsal extensions, pleural ridge extending to base of halter anteriorly, and behind this a second bar, apparently sclerotized posterior margin of metepimeron. Venter with a well-developed precoxal ridge extending medially to vicinity of metasternal apophyses. A definite metasternite present, composed of discernible metasternal apophyses, linked by a well-defined metasternellum. Forewings well developed, about 3.2 mm. long, both surfaces covered with microtrichia.

Halteres (fig. 1, E) well developed, about 300 μ long, each bearing four crook-shaped setae on distal end; these setae about 75 μ long from base to outermost curve of crook. Legs elongate, slender; hind femora about 0.75 mm. long; hind tibae about 1.13 mm. long; hind tarsus about 0.28 mm. long; tarsal claw about 75 μ long. Tarsi 2-segmented, basal segment small, triangular. Tarsal claws (fig. 1, F) each with a distinct preapical denticle on its inner face; a pair of stout spine-like projections on inner face near base; and a pair of digitules, each about 36 μ long, fairly stout basally and tapering to a fine point. Trochanters, femora, and tibiae clothed with long, fine setae about 195 μ maximum length; tibiae and tarsi thickly set with short spiniform setae along inner face; tarsi with short slender setae, about 48 μ maximum length, along outer face. Trochanters each bearing 6 or 7 circular sensoria.

Abdomen largely membranous, clothed with segmentally arranged bands of long fine setae. Setae longest near lateral margins, up to about 165 μ maximum; mid-dorsal and mid-ventral setae somewhat shorter, about 120 μ maximum length. Abdominal sclerotization consisting of four pairs of small dorsal inter-

segmental spots, one spot on either side of mediodorsal axis between segments 2 and 3, 3 and 4, 4 and 5, and 5 and 6,[1] each spot incompletely to completely divided along intersegmental line, spots progressively smaller posteriorly. Ninth segment with a well-developed median transverse sclerite dorsally (fig. 3, H) and a sublateral sclerotized spot on each side ventrally.

Postero-lateral margins of 9th abdominal segment each with a conspicuous cerarius (fig. 3, A); each cerarius consisting of a deeply invaginated pocket lined on its upper and lower inner faces with numerous stellate pores. Inner apex of each cerarial pocket bearing a pair of stout setae, each about 200 μ long, tapering to a blunt, rounded apex. Each pocket set with about 250 stellate pores and bearing a few slender accessory setae. Stellate pores (fig. 3, B) each 9 or 10 μ outside diameter, 6 or 7 μ inside diameter. Dorsal margin of each pocket bearing a row of slender setae, up to 130 μ long, which extends transversly across posterior margin of 9th segment. Tenth segment membranous dorsally.

Penial sheath (fig. 3, E, F) about 0.60 mm. long. Anterior and lateral margins formed of a strongly sclerotized triangular framework. Sclerotized portion of each lateral margin incompletely divided by what appears to be a weak sutural line. Posterior extension narrow, apex rounded in ventral aspect; broader in lateral aspect, upper margin hook-shaped (fig. 3, E). Sclerotized lateral margins of penial sheath bearing numerous slender setae about 75 μ maximum length; these continuing onto membranous portion of sheath near its anterior margin. Aedeagus strongly sclerotized and elongate, basal portion attached to sclerotized lateral margins of sheath by a broad apparently retractable membranous area. Exerted portion of aedeagus about 1 mm. long, tapering apically to a bifurcated tip. Tip (fig. 3, G) set with minute spines.

Body bearing numerous small dermal disc pores, each with 4 or 5 peripheral loculii (fig. 3, C, D); inside diameter of pores about 4 or 5 μ, outer rim of irregular width, outside diameter usually about 8 μ; these pores distributed in scattered groups of 8 to 12 on lateral margins of each abdominal segment, rows of 6 to 8 across dorsum of abdominal segments, and 2 or 3 on venter of most abdominal segments, rather numerous on membranous portions of thorax, and on anterior membranous parts of head, a dozen or so ventrally and 2 or 3 dorsally on each side of midcranial ridge.

Described from 4 slide-mounted specimens: 2, Tanbark Flat, San Gabriel Mts., California, July, 1950, J. W. Beardsley, flying; 2, Alder Springs, Glenn Co., California, July 7, 1953, H. H. Keifer, *ex Arctostaphylos*. The description above is based largely on the two specimens from Tanbark Flats, as the slide preparations of these were superior. Although these specimens were not taken in association with females, they agree in all essential details with the Alder Springs specimens. The latter were definitely associated with females which agree with Ferris' (1950) concept of *P. yuccae*, and all four males are considered to belong to that species.

[1] The first discernible segment dorsally is considered as segment 2 (see Beardsley 1960, pp. 205–206).

The male of *Puto yuccae* differs in several important respects from males of other mealybug species which I have examined. In general, *P. yuccae* males appear definitely more primitive (*i.e.*, less degenerate) than do the males of mealybugs belonging to other genera. This is in accord with evidence presented by coccid cytogeneticists (Hughes-Schrader, 1948 and others), and supports the thesis that *Puto* and related genera represent a relatively primitive pseudococcid stock. The possession in *Puto* of a row of small, simple eyes around the anterior margin of the ocular sclerites, instead of the dorsal and ventral pairs of eyes which are encountered in other mealybug males, is of particular interest. These rows of eyes, which are presumably homologous to the individual ommatidia of the compound eyes of male Margarodidae and Ortheziidae, appear to be characteristic of *Puto* males and have been described in males of *P. ambigua* (Fullaway) (1910), *P. antennatus* Signoret, and *P. superbus* (Leonardi) (Reyne, 1954). In this respect, *Puto* males resemble those of the anomalous margarodid *Steingelia gorodetskia* Nassonow, which has been described and figured by Morrison (1928) and Theron (1958). The single eye on each side behind the anterior row is presumed to be homologous with the lateral ocelli of margarodid and ortheziid males and with the lateral eyes of other pseudococcid males. The head of the *P. yuccae* male also exhibits a somewhat stronger development of the midcranial and postocular ridges than that found in other species of pseudococcids which I have examined.

The thorax of the *Puto yuccae* male seems to have undergone less extensive sclerite degeneration than that encountered in males of other species. The propleurites are relatively large, and the prosternum and prosternal apophyses are well developed. The metapleura of *Puto yuccae* also are more strongly developed than in other mealybug males that I have seen. In addition to the metapleural ridge, they possess a second dorsally directed sclerotized bar originating on the posterior margin of the metapleuron; a structure which has not been reported in other species. Both meso- and metapleura each bear a small ventrally directed bar behind the precoxal ridge which seems to be homologous with the structure which Giliomee termed a trochantin, and which he found associated with the mesothoracic pleurites of the species which he studied. The metasternal apophyses are well developed in *P. yuccae* males, and these are linked by a definite metasternum. Theron (1958) considered the presence of metasternal apophyses and metasternum as primitive characters not found in pseudococcids and other lecanoid groups. Giliomee has demonstrated the presence of metasternal apophyses in the three species of *Pseudococcus* which he studied, but found no metasternal plates.

The presence of four hooked setae at the apex of the halter in the male of *Puto yuccae* is a feature reminiscent of margarodid males. In other male pseudococcids which I have seen, each halter bears but a single terminal seta. Reyne (1954) found that in males of *Puto antennata* the number of hooked setae on the halteres varied from one to four in different individuals.

From Fullaway's description and figures of the apterous male of *Puto ambigua*, it appears that, except for the absence of wings, the male of that species is quite similar to that of *P. yuccae*. Fullaway's figure shows 16 simple eyes arranged on the head as in *P. yuccae*, and from his illustrations the aedeagus and penial sheath of *P. ambigua* appear to be very similar to those of *P. yuccae*.

Reyne's 1954 paper on the European *Puto antennatus* Signoret includes a detailed description and figures of the male. Reyne also examined males of *P. yuccae*, described and illustrated certain morphological structures of that species (*i.e.*, head, tip of aedeagus) and made comparisons with males of the European forms. Reyne concluded, primarily on differences in the structure of the male genitalia and eye number, that the American and European species of *Puto* represent different lines of development. He also agrees with Borchsenius who (1948) re-erected the genus *Macrocerococcus* Leonardi (genotype *M. superbus* Leonardi), and he gives a key to separate the genotypes of the three genera of the *Puto* complex in Europe (*Ceroputo* Sulc, *Macrocerococcus* Leonardi, and *Puto* Signoret). Reyne's recognition of *Macrocerococcus* and *Ceroputo* is not in accord with the findings of Ferris (1950, pp. 190–191) and Balachowsky (1953) both of whom consider *Macrocerrococcus* and *Ceraputo* synonyms of *Puto*. The existence of these divergent opinions concerning the status of *Puto* and related genera, and the existence of significant morphological differences between the males of the few species in which this sex has been studied, suggests that a comparative study of the males of as many species as can be obtained might contribute a great deal toward a better understanding of this group of mealybugs.

The genitalia of the *Puto* male exhibit a certain superficial resemblance to those described by Morrison (1928) for the atypical margarodid *Stomacoccus plantani* Ferris and, to a lesser extent, to *Steingelia gorodetskia* Nassonow, the male of which has been described and figured by Morrison (1928) and Theron (1958). These two species constitute the atypical margarodid subfamily Steingeliinae Morrison. Theron has pointed out that the male of *Steingelia* differs in several important respects from those of other margarodids, having several characters in common with the more specialized coccids. Green (1920) suggested that *Steingelia* may constitute a connecting link between the Margarodidae and the Pseudococcidae, and the morphology of the *Puto* male appears to support this hypothesis.

Phenacoccus gossypii Townsend and Cockerell.

My 1960 description of the male of this species was based on two Hawaiian specimens. Since then I have examined additional material obtained from laboratory cultures maintained by the University of California Department of Genetics at Berkeley. The specimens studied agree in all essential detail with the Hawaiian specimens previously described, and the better slide preparations which were obtained from the Berkeley material have clarified some doubtful points concerning the structure of the penial sheath of this species. In my 1960 paper I stated

that the extent of the median ventral slit of the penial sheath, present in the males of all other mealybugs studied, was not discernible in this species. Examination of additional material indicates that a ventral slit of the type occurring in *Pseudococcus* and related genera does not occur in *P. gossypii*, except in the apical one-third or so of the sheath, and that the venter of the basal two-thirds of the sheath forms a membranous attachment to the base of the aedeagus, somewhat like that of *Puto yuccae*.

Another feature of the penial sheath of *Phenacoccus gossypii* which was not mentioned previously is the apparently two-segmented structure of this organ. There appears to be a definite transverse indentation or suture which separates the apical third of the sheath from the basal part (fig. 2, I). The basal part appears to consist of a basal and lateral sclerotized framework plus the membranous venter which is attached to the base of the aedeagus. The apical third, including the prolonged tip, is more heavily sclerotized and does not appear to possess a ventral membrane. Dorsally, the basal two-thirds of the sheath is largely membranous except along its posterior margin where there is a transverse sclerotized band beneath which lies what is apparently the anal opening. Among the other mealybug males which I have examined, only those of *Rhizoecus falcifer* exhibit this two-segmented type of penial sheath. Morrison's (1945) figure of the male of *Heterococcus graminicola* suggests strongly that this type of penial sheath occurs in that species also. The occurrence of this type of penial sheath in *R. falcifer* suggests a possible relationship between *Rhizoecus* and the *Phenococcus* group of mealybug genera.

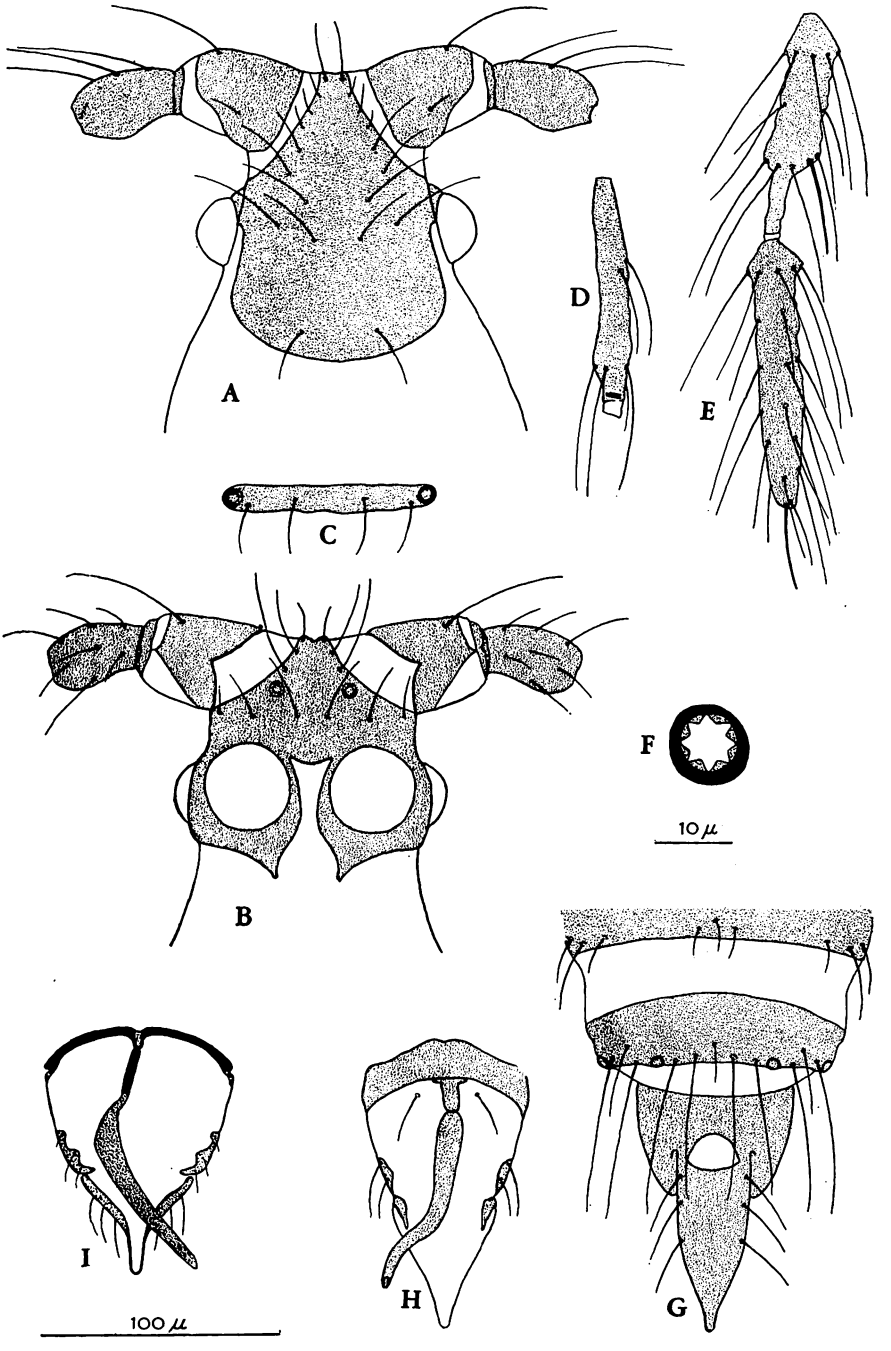
Rhizoecus falcifer Kunckel d'Herculais.

Rhizoecus falcifer Kunckel d'Herculais, 1878. ANN. ENT. SOC. FRANCE 8 (ser. 5):164.

Male. Length of body on slide about 1.0 mm.; available specimens macropterous. Antenna 10-segmented, nearly as long as body (about 0.94 mm.) Scape and pedicel relatively short and stout (fig. 2, A); scape about 45 μ long by 45 μ wide at base; pedicel about 48 μ long by about 30 μ maximum width. Flagellar segments elongate, slender, measuring about 105:110:100:100:93:93:90:112 μ respectively, second to sixth conspicuously binodose. Antenna clothed with long slender filamentous setae about 65 μ maximum length; apical segment with 2 or 3 slightly thicker specialized sensory setae about 50 μ long; penultimate segment with one such seta in outer whorl (fig. 2, D, E).

Head (fig. 2, A, B) with a broad, well-developed dorso-medial sclerite covering most of dorsum, and extending forward and downward between antennae as

FIG. 2. A–H, *Rhizoecus falcifer:* A, dorsal aspect of head; B, ventral aspect of head; C, vestigial pronotal ridge; D, 3rd antennal segment; E, 9th and 10th antennal segments; F, dermal disc pore (enlarged); G, dorsum of 9th abdominal segment and penial sheath; H, ventral view of penial sheath and aedeagus; I, *Phenacoccus gossypii*, ventral view of penial sheath and aedeagus.


A
B
C
D
E
F
10 μ
G
H
I
100 μ

a broad midcranial ridge. Ventral and lateral portions of head occupied by a pair of well developed ocular sclerites; these separated ventrally, between ventral eyes by a membranous strip. Each ocular sclerite bearing two conspicuous, simple eyes; a large ventral eye about 36 μ in diameter, and a smaller lateral eye about 27 μ in diameter. Head broadly joined to thorax, without a well-defined neck.

Thoracic sclerotization less strongly developed than in other winged mealybug males. Propleural areas broadly but weakly sclerotized; propleural ridge (which in other species is joined to cervical aclerite) extending forward for a short distance beyond coxal articulation and then becoming evanescent. Cervical sclerites not discernible. Anterior pronotal ridge represented only by a weakly sclerotized, mid-dorsal transverse band (fig. 1, C). Prosternum represented by a roughly triangular area of weak sclerotization and a pair of small, prosternal apophyses. Sclerotization of mesothorax normally developed but with metasternal furca relatively small. Metathoracic sclerites very weakly developed, represented by a pair of small metapleura and a barely discernible metapostnotum.

Mesothoracic wings well developed, more elongate and slender than in other male pseudococcids studied, about 1.0 mm. long by 0.27 mm. maximum width. Metathoracic wings ("halteres") completely absent. Metapleural ridge (which in other winged males extends from metapleurite to base of halter) wanting. Legs well developed, slender; hind femora about 115 μ long; hind tibiae about 210 μ long; hind tarsus about 93 μ long; tarsal claws slender, those of hind legs about 32 μ long, bearing a pair of fine digitules about 25 μ long. Tarsi 2-segmented, basal segment narrow, triangular, about 9 μ long on its inner, longer face. Coxae, trochanters, femora, and tibiae sparsely clothed with slender filamentous setae about 36 μ maximum length; a double row of setae along inner margin of tibiae which become progressively thicker and more spiniform apically, apical spines considerably thicker than filamentous setae. Tarsi with a double row of spine-like setae along inner face; other setae of tarsi filamentous. Head and thorax sparsely clothed with slender, filamentous setae, mostly 36 to 40 μ long.

Each abdominal segment anterior to penial sheath with a weakly developed, transverse sclerite extending completely across dorsum; intersegmental areas unsclerotized. Venter of each abdominal segment bearing a similar weakly developed, transverse area of sclerotization; that of segment 3 (first discernible segment ventrally) relatively narrow, those of segments 4 and 5 wider, those of segments 6 to 9 progressively narrower; segments 5 to 8 each with a separated, small, seta-bearing area of weak sclerotization on each lateral margin.

Penial sheath (fig. 2, G, H) about 126 μ total length; apparently composed of two incompletely fused segments. Dorsum and sides moderately well sclerotized; ventral portion around base of aedeagus largely membranous; dorsum bearing conspicuous anal opening. Distal part of sheath tapering to a rounded tip, about 9 μ wide at 9 μ before apex. Aedeagus tubular, approximately 90 μ long,

apical portion extending outward and downward in a shallow sigmoid curve; apex bifurcate, forks converging, forming a pair of very fine points at tip.

Abdomen without long, tail-forming setae and associated pore clusters. Dorsal posterior margin of 9th segment with a conspicuous row of about 10 long setae, 60 to 75 μ long, longest near lateral margins (fig. 2, G). Ventral sclerites of abdomen each with a row of filamentous setae about 30 μ maximum length along its posterior margin; dorsal abdominal sclerites each with a similar row of setae near its center; a group of usually longer setae, up to about 45 μ long, on lateral margins; small, separated, lateral sclerotized areas each bearing a pair of filamentous setae about 30 to 40 μ long.

Dermal pores (fig. 2, F) relatively large, about 9 or 10 μ outside diameter, 6 or 7 μ inside diameter, and few in number; stellate, with 6 to 8 peripheral loculii. Four such pores on posterior margin of dorsum of 9th abdominal segment (fig. 2, G); 2 on each lateral margin of venter of 2nd abdominal segment; 1 adjacent to and 2 above each mesothoracic spiracle, 2 or 3 on each side of prothorax just above procoxal articulation; a pair midventrally near anterior margin of prothorax; one on each end of vestigial pronotal ridge dorsally (fig. 2, C); one just above each anterior spiracle; 1 or 2 on each side of venter of head anteriorly between bases of antennae (fig. 2, B).

Described from 6 specimens: *ex* laboratory culture on potato tubers, Berkeley, California, September, 1960, provided by Dr. Uzi Nur.

The male of *R. falcifer* differs rather strikingly in several important respects from males of any other mealybug I have seen. The head bears but two pairs of eyes, and these appear to represent the large dorsal and ventral eyes encountered in most other winged male pseudococcids. The small, lateral ocelli found in other species are wanting, and it appears that the dorsal pair of eyes has migrated to a lateral position and the dorso-medial sclerite has in consequence become broader and more strongly developed than in other male mealybugs.

The head of the male of *Rhizoecus falcifer* is not separated from the thorax by a constricted "neck" region as in all other species I have seen. The conspicuous narrow postocular ridge found in males of *Puto* and other genera is not discernible as such in *R. falcifer*. The area anterior to the ventral eyes between the bases of the antennae appears to be weakly sclerotized in *R. falcifer*, but the narrow well-defined midcranial ridge found in males of other species is not discernible here. The absence of cervical sclerites and the reduction of the pronotal ridge on the anterior margin of the prothorax are features which have not been reported in other mealybug males. The absence or reduction of these structures suggests that head of *R. falcifer* is more rigidly attached to the thorax than in other mealybug males, and in this respect it resembles, somewhat, the males of the armored scales (Diaspididae). Other unusual features of the male of *R. falcifer* are the complete absence of the metathoracic wings ("halteres"), and the absence of any definite tail-forming cerarii composed of long setae and associated clusters of stellate pores.

The structure of the penial sheath of *Rhizoecus falcifer* seems most similar to that of *Phenacoccus gossypii* among the species which I have examined. The largely membranous ventral portion of the sheath and the apparently 2-segmented nature of this organ are a combination of features which I have encountered only in these two species, although I suspect that this type of penial sheath may be of general occurrence among the males of species belonging to the *Phenacoccus* group of genera. This similarity in structure of the male genitalia suggests the possibility that the *Rhizoecus* and related genera may be more closely allied to *Phenacoccus* and its relatives than to *Trionymus*, for example, which the females resemble in certain respects.

Pseudococcus comstocki (Kuwana).

Dactylopius comstocki Kuwana, 1902. PROC. CALIF. ACAD. SCI. 3:52.
Pseudococcus comstocki, Fernald, 1903. CAT. COCCIDAE OF THE WORLD, p. 100.

Male. Body length about 1.33 mm. on slide; available specimens macropterous. Antenna 10-segmented; about 0.60 mm. total length; 3rd segment about 75 μ long. Antenna clothed with digitiform setae about 33 μ maximum length plus a few slender filamentous setae about 42 μ maximum length; thicker specialized sensory hairs on 3 apical segments about 48 μ maximum length.

Head without a noticeably developed dorso-medial sclerite; with a well-developed midcranial ridge dorsally. Ocular sclerites heavily sclerotized dorsally, ventral portions less strongly sclerotized except between and around sockets of ventral eyes; posterio-dorsal corners of ocular sclerites linked by a U-shaped band extending behind dorsal terminus of midcranial ridge. Head with usual three pairs of eyes; dorsal pair each about 34 μ in diameter; ventral pair each about 39 μ in diameter.

Dermal discs mostly with 4 peripheral loculii, occasionally with 3 or 5 such loculii; distributed 4 or 5 on each side of abdominal segment 7, 1 to 3 each side of abdominal segments 3 to 6, 5 to 7 each side of segment 2, 4 or 5 each side of prothorax, usually 2 on venter of prothorax between coxae, 2 or 3 on each side of midcranial suture on front of head between antennae. Tail-forming pore clusters limited to pair on 9th abdominal segment; each cluster composed of 50 to 60 closely packed stellate pores. Bases of tail-forming setae of each cerarius set in a small cup-shaped depression closely packed with stellate pores; these pores noticeably smaller than those outside the depression. Body moderately densely clothed on both dorsum and venter with digitiform setae mostly 22 to 30 μ long, intermingled with a few slender filamentous setae 20 to 30 μ long.

Penial sheath (fig. 3, I) about 120 μ total length, without discernible median lobes. Posterior extension broadly rounded or nearly truncate; about 18 μ wide at 9 μ before tip.

Legs of moderate length; hind femora about 200 μ long; hind tibiae about 270 μ long, clothed with digitiform setae about 30 μ maximum length, plus a

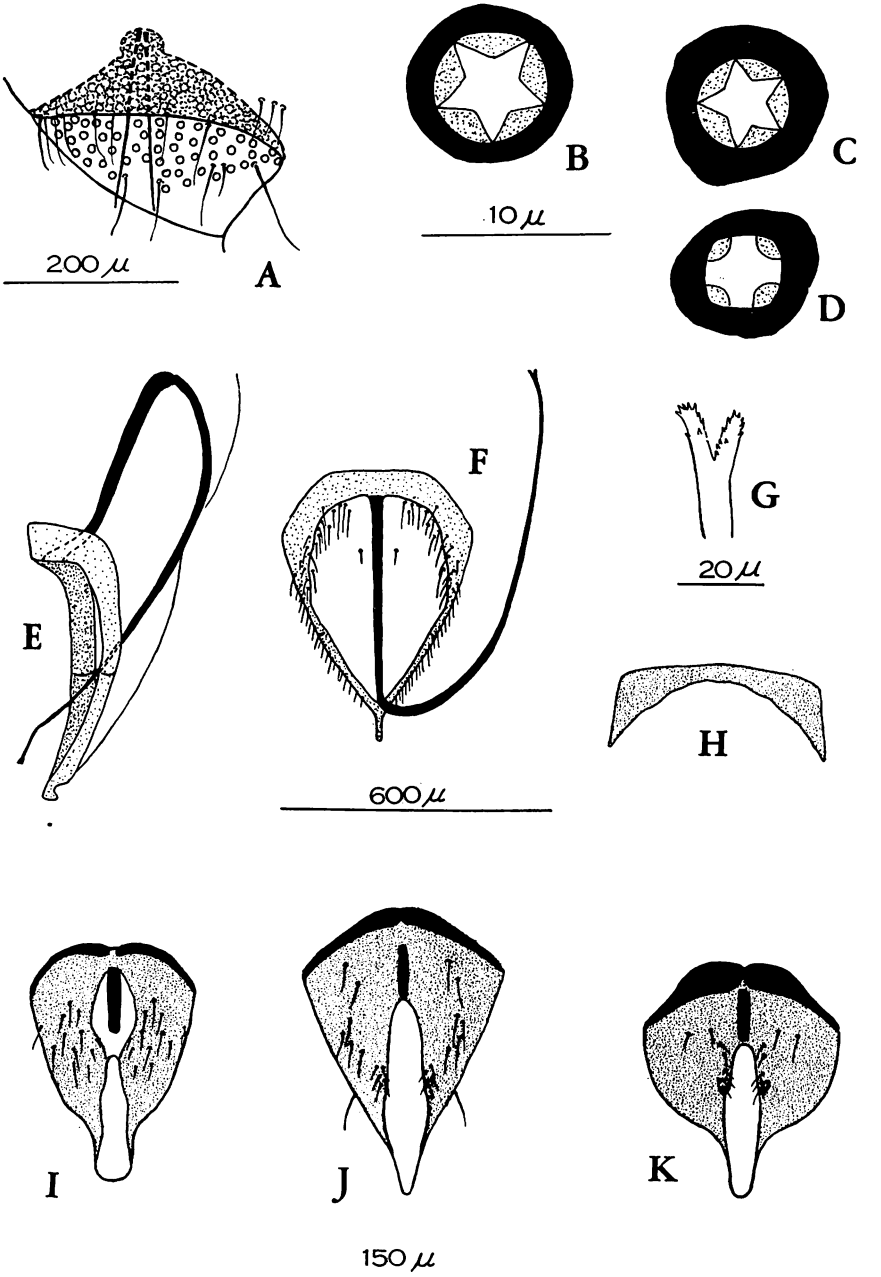


FIG. 3. A–H, *Puto yuccae:* A, dorsal aspect of cerarial pocket; B, stellate pore of cerarius: C and D, types of dermal disc pores; E, lateral view of penial sheath with aedeagus retracted (setae omitted); F, lateral view of penial sheath with aedeagus extended; G, tip of aedeagus enlarged; H, tergite of 9th abdominal segment; I, *Pseudococcus comstocki*, penial sheath; J. *Pseudococcus fragilis*, penial sheath; K, *Pseudococcus peleae*, penial sheath.

few slender filamentous setae of comparable length, apices of tibiae with several thicker spines along posterior margin of lower surface. Claw of hind tarsus about 38 μ long.

Abdominal sclerotization consisting of a broad transverse patch on dorsum of segment 9, a similar, somewhat more elongate patch on venter of segment 9, an irregular transverse patch on dorsum of segment 10 over penial sheath, usually a small pair of dorsal intersegmental patches between segments 2 and 3, and sometimes similarly between segments 3 and 4. Bases of setae on dorsum of 8th abdominal segment sometimes surrounded by rings of weak sclerotization.

Based on 4 specimens: Nashville, Tenn., May 6, 1961, *ex* laboratory culture on potato sprouts, colony originally from yew, collected by Uzi Nur; one specimen from Okitsu, Shizuoka-ken, Japan, Sept. 23, 1939, R. W. Burrell, *ex* sand pear. This Japan specimen was loaned to me through the courtesy of Dr. Harold Morrison, USDA, Washington, D.C., and agrees in all essential details with the Tennessee specimens.

As with most other mealybug males which I have examined, the size and shape of the penial sheath distinguish males of *P. comstocki*. Among the males of *Pseudococcus* (in the sense of Ferris, 1950) the absence from the penial sheath of median lobes in *P. comstocki* suggests that this species may not be closely allied to the genotype, *P. adonidum* (L.).

Pseudococcus fragilis Brain.

Pseudococcus fragilis Brain, 1912. ANN. ENT. SOC. AMERICA 5:186.

Pseudococcus gahani Green, 1915. ENT. MONTHLY MAG. 51:179.

Pseudococcus citrophilus Clausen, 1915. UNIV. CALIF. AGR. EXT. BULL. 258:30.

Pseudococcus gahani, Ferris 1950. ATLAS OF THE SCALE INSECTS OF NO. AMER. 5:180, fig. 67.

Pseudococcus fragilis, De Lotto 1958. BRITISH MUS. (NAT. HIST.) BULL. ENT. 7(3):96.

Pseudococcus fragilis, Giliomee 1961. ANN. UNIV. STELLENBOSCH 36(A)6:263 (description of male).

Male. Length on slide about 1.60 mm.; available specimens macropterous. Antenna 9- or 10-segmented, 0.80 to 0.93 mm. long; 3rd segment elongate, about 144 μ long. Antenna clothed with slender, elongate, digitiform setae about 50 μ maximum length; plus a very few scattered, slender, filamentous setae about 36 μ long. Thicker specialized sensory setae on 3 apical segments about 60 μ maximum length.

Head with a prominent midcranial ridge dorsally, dorsomedial sclerite weakly developed, its posterior margin marked by a pair of moderately well-developed, arcuate bands. Usual 3 pairs of eyes present; dorsal pair about 39 μ in diameter; ventral pair about 42 μ in diameter.

Dermal discs with 4 peripheral loculii; distributed on lateral margins of abdomen, 3 to 5 on each side of segment 8, 1 to 3 each side of segments 4 to 7, absent on segment 3, 6 to 11 on each side of segment 2; 6 to 8 on each side of prothorax, plus a transverse row of 6 or so across dorsum of prothorax near its posterior border; 1 or 2 each side of metathorax, above and behind bases of halteres; a row of 3 or 4 on each side of front of head beginning between base of antennae and extending upward toward the dorsal eyes. Tail-forming cerarii confined to one pair on 9th abdominal segment; each containing a closely packed cluster of about 90 to 100 stellate pores. Bases of long tail-forming setae of each cerarius recessed within a small pocket lined with densely packed stellate pores of somewhat smaller size.

Body moderately densely clothed with elongate digitiform setae about 45 μ maximum length; intermixed with slender filamentous setae about 40 μ maximum length; digitiform setae slightly more numerous than filamentous type.

Penial sheath (fig. 3, J) about 150 μ total length, without discernible median lobes; posterior portion tapering uniformly to a moderately acute point about 9 μ wide at 9 μ before tip.

Legs moderately long, hind femora about 265 μ in length, hind tibae about 340 μ long; clothed with long digitiform setae about 56 μ maximum length, plus a few slender filamentous setae about 30 μ maximum length. Claw of hind tarsus about 42 μ long.

Abdominal sclerotization consisting of a broad irregular median transverse band on dorsum of segment 9; a similar but somewhat shorter and wider band on venter of segment 9.

Based on 4 slide mounted specimens; Albany, California, August 1960, *ex* laboratory culture on potato sprouts, furnished by Mr. Glen Finney.

The form of the penial sheath in combination with the presence of abundant long digitiform setae on the body and appendages will permit the ready separation of *P. fragilis* males from those of all other species which I have studied. The penial sheath of this species resembles, somewhat, that of *P. citriculus* Green in general form, although considerably smaller. The penial sheath is also similar to that of *Laminicoccus giffardi* (Ehrhorn), but males of that species have relatively short antennae and short digitiform setae. On the bases of the males alone, the species does not appear to be particularly closely allied to *P. adonidum*.

Giliomee's very detailed description of the male of this species did not become available until after I had prepared the preceding, rather brief description. The males from California which are at hand seem to agree quite well with Giliomee's description, and on the basis of this evidence and that cited by De Lotto (1958), I have accepted the conclusion of the latter author that *P. gahani* Green should be considered a synonym of *P. fragilis*.

Pseudococcus peleae Beardsley.

Pseudococcus peleae Beardsley, 1959. PROC. HAW. ENT. SOC. 17(1):47.

Male. Body length on slide about 1.30 mm.; available specimens macropterous. Antenna 10-segmented, about 665 μ total length; 3rd segment about 90 μ long; clothed with slender digitiform setae about 37 μ maximum length, plus a few slender filamentous setae of about same length. Thicker specialized sensory setae of three apical segments up to 54 μ long.

Head with a well-developed, dorsal, mid-cranial ridge; dorsomedial sclerite not strongly developed. Usual 3 pairs of eyes present; dorsal pair each about 36 μ in diameter; ventral pair each about 43 μ in diameter.

Dermal discs mostly with 4 peripheral loculii, a few with 3 or 5 such loculii; distributed on lateral margins of abdomen, 2 on each side of segment 8, one each side of segments 3 to 7, 5 or 6 each side of segment 2; 2 midventrally on prothorax between coxae; 3 or 4 on each side of prothorax; 2 each side of front of head between bases of antennae. Tail-forming cerarii confined to pair on 9th abdominal segment, each containing a cluster of about 80 to 90 stellate pores; tail-forming setae of each cerarius set in a small cup-shaped depression lined with close-packed stellate pores slightly smaller than others.

Body moderately, sparsely clothed with digitiform setae about 30 μ maximum length, plus a few slender filamentous setae about 27 μ maximum length.

Penial sheath (fig. 3, K) about 124 μ total length; median lobes represented by barely discernible humps; posterior extension tapering to a rounded apex about 16 μ wide at 9 μ before tip.

Legs of moderate length; hind femora about 210 μ long; hind tibiae about 260 μ long; claw of hind tarsus about 40 μ long. Legs clothed with digitiform setae about 36 μ maximum length plus a very few shorter slender filamentous setae.

Described from 6 slide-mounted specimens: North Halawa Ridge, Koolau Mts., Oahu, 2,000 ft. Oct. 1, 1960, J. W. Beardsley, on leaves of *Pelea clusiaefolia*. This species will run to couplet 16 in my 1960 key to males of Hawaiian mealybugs. It most closely resembles the male of *Clavicoccus tribulus* Ferris, from which it may be separated by its larger penial sheath, slightly smaller dorsal and ventral eyes, and less numerous abdominal dermal discs.

DISCUSSION

Perhaps the most striking feature so far apparent from studies on male pseudococcids is the absence of clear-cut characters in the males corresponding to those which have been used to separate and define genera in the female sex. Except for what probably should be considered major divisions within the Pseudococcidae (*e.g.*, the primitive *Puto* group, the *Phenacoccus* and *Pseudococcus* lines) examination of the males has not yet elicited characters which can be used to group the species into genera corresponding to those which have been

erected to receive their female counterparts. Had the study of the Pseudococcidae been based primarily on the male sex rather than on the females, it is probable that the number of described genera would be very much smaller than it is today. It seems likely that the presently accepted generic classification of the mealybugs is somewhat artificial, and may be based in part on characters which are not of fundamental significance. This appears to have led to excessive "splitting" of older mealybug genera in recent years, and to the retention of possibly polyphyletic "residue" genera as well.

If, for example, the genus *Pseudococcus* were restricted to those species with males possessing penial sheaths of the general type of the genotype, *P. adonidum* (well-developed median lobes, truncate apex), then the only other species for which males are known which could be included in the genus would be a group of endemic Hawaiian species (*P. floriger* Ferris, *P. antricolens* Ferris, *P. dorsispinosus* Beardsley, *P. lycopodii* Beardsley, and several undescribed species) and an undescribed form from Micronesia. The females of some of these, if the Ferris definition of *Pseudococcus* is accepted, could not be retained within that genus. On the other hand, several species placed by Ferris in *Pseudococcus sens strict.* [*e.g.*, *P. maritimus* (Ehrhorn), *P. fragilis* Brain, *P. citriculus* Green, *P. comstocki* (Kuwana)] would, on the basis stated, logically have to be removed from *Pseudococcus*.

Ferris himself pointed out (1950) that a sound generic classification of the Pseudococcidae must take into account both sexes. I feel that a comprehensive study of pseudococcid males would do much toward clarifying relationships within the group. In the meantime, until such a study is forthcoming, it seems to me that the continuing fragmentation of the older mealybug genera, often based on what seem to be rather arbitrary limits of certain characters of the females (as the separation of *Dysmicoccus* from *Trionymus* and from *Pseudococcus*) is not a sound taxonomic procedure, as it adds little to our understanding of the group as a whole.

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